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SCIENTIFIC CRITERIA DOCUMENT FOR THE DEVELOPMENT OF A PROVINCIAL WATER QUALITY GUIDELINE FOR TOLUENE

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SCIENTIFIC CRITERIA DOCUMENT FOR THE DEVELOPMENT OF A PROVINCIAL WATER QUALITY GUIDELINE FOR TOLUENE

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The public were notified of the proposed Provincial Water Quality Guideline for toluene through the Environmental Bill of Rights Electronic Registry and given the opportunity to comment in accordance with the Environmental Bill of Rights.

PREFACE

The Ontario Ministry of Environment and Energy (MOEE) develops Provincial Water Quality Objectives or Guidelines for those substances deemed to be of environmental concern in Ontario as determined through a screening process which considered persistence, potential to bioaccumulate, acute and chronic toxicity, and potential presence in the aquatic environment. In addition, Ministry staff with a direct responsibility for managing possible effects of contaminants may request an evaluation.

Provincial Water Quality Objectives and Guidelines (PWQO/Gs) are numeric or narrative criteria intended to protect all life stages of aquatic organisms for indefinite exposures and/or they are intended to protect recreational uses of water. Objectives or guidelines do not take into account analytical detection or quantification limits, treatability or removal potential, socio-economic factors, natural background concentrations, or potential transport of contaminants among air, water and soil. They represent a desirable water quality for the protection of designated uses of surface waters in Ontario.

The process for deriving these criteria is detailed in Ontario's Water Quality Objective Development Process (1992) and is available from the ministry's Public Information Centre, 135 St. Clair Avenue, Toronto, Ontario M4V 1P5 (Tel. (416) 323-4321 or 1-800-565-4923). The toxicology literature is reviewed for all of the following areas: aquatic toxicity, bioaccumulation, mutagenicity and aesthetic considerations. The final criterion is based on the lowest effect reported for any of these. Where numeric criteria are set to protect aquatic life, the number is derived by dividing the lowest adverse effect concentration by a safety factor for Objectives or an "uncertainty factor" for Guidelines. The size of the uncertainty factor reflects the quality and quantity of data available and the potential of the material to bioaccumulate.

Policies and procedures which govern the uses of PWQO/Gs are contained in the booklet - Water Management (1984) - which deals with all aspects of Ontario's water management policy. These policies and procedures make provision for considering such factors as natural background levels, socio-economic factors, treatability, and the waste assimilative capacity of the receiving environment in applying the PWQO/Gs in site-specific situations. PWQO/Gs are used to: i) classify receiving waters for water management purposes; ii) assess contaminant discharges to the aquatic environment; and iii) derive water quality-based effluent limits which may be included in Certificates of Approval which are issued to regulate effluent discharges. Where better water quality is required to protect other beneficial uses of the environment in a given location, appropriate criteria and factors, including public health considerations, are taken into account.

EXECUTIVE SUMMARY

A Provincial Water Quality Guideline (PWQG) was developed for toluene for the protection of aquatic life. The physical-chemical properties, aquatic toxicity, bioaccumulation potential, taste and odour characteristics, and genotoxicity potential of toluene were considered in developing the guideline.

Toluene is a clear colourless liquid that occurs naturally in coal and crude oil and is found in many consumer products including gasoline, cosmetics, and cleaners. It may enter the environment from releases associated with its production, use, storage and transportation, including petroleum spills. In Ontario, the major producers of toluene are located near Sarnia. Some important dischargers of toluene into surface waters are the chemical manufacturing, petroleum refining, and pulp and paper sectors.

Natural processes can remove toluene from land, air, and water and reduce environmental exposures. As a result, ambient levels remain low and there is little tendency for toluene levels to build up in the environment over time. In Ontario, surface water concentrations are usually less than 0.001 mg/L or they are not detectable and atmospheric concentrations are generally less than 10 $\mu g/m^3$. The lowest MOEE detection limit for routine analysis of toluene in water is 0.00005 mg/L.

Toluene is highly toxic to aquatic organisms when water concentrations exceed 5 mg/L during short-term exposures or reach 0.02 mg/L during long-term exposures. Reported levels of toxicity include a 96h-LC50 (median lethal concentration) of 5.46 mg/L for coho salmon fry (Moles et al. 1981) and a 24h-EC50 of 7 mg/L for the immobilization of water fleas (Galassi et al. 1988). Black et al. (1982) reported a 27d-LC50 of 0.02 mg/L for exposure of early life stages of rainbow trout.

The Provincial Water Quality Guideline of 0.0008 mg/L was derived by dividing the lowest adverse effect concentration (0.02 mg/L) by a final uncertainty factor of 26. Since the water quality criterion for the protection of aquatic life is more stringent than the odour, tainting and taste protection values derived for toluene, it is recommended as the PWQG.

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1.0 INTRODUCTION

Toluene (C_7H_8) is a clear colourless liquid with a sweet odour. It occurs naturally in crude oil and is found in many consumer products such as gasoline, nail polish, cosmetics, rubber cement, paint brush cleaners, stain removers, fabric dyes, inks, and adhesives used for packaging of food (ATSDR 1989).

In 1982, the major use of toluene in Canada was as a solvent in consumer products, lacquers, resin solutions, lacquer thinners, and pesticides (Environment Canada 1984). Toluene was also used for manufacturing benzene and benzoic acid/phenol.

The major Ontario producers of toluene are located in Sarnia (Esso Chemical Canada and Sunchem) and Corunna (Polysar Energy and Chemical, and Shell Canada). Ontario nameplate production capacity in 1987 was 495 kilotonnes per year (Corpus Information Services Limited 1988). There are at least 20 major Ontario buyers of toluene (Corpus Information Services Limited 1988). Most buyers are located in Metropolitan Toronto with others in Oshawa, Mississauga, Cornwall, Ajax, Oakville, Brampton, Guelph, Brantford, London, and Corunna.

The effects of toluene on human health have been recently reviewed (RTECS 1993; IRIS 1992; ATSDR 1989; Health and Welfare Canada 1988). Limited health effects information is available regarding dermal exposures to aqueous solutions of toluene. The U.S. Environmental Protection Agency has given toluene a cancer rating of "D" (not classifiable as to human carcinogenicity because of a lack of human data and inadequate animal studies). The U.S. EPA has also developed an oral reference dose of 0.22 mg/kg/day (equivalent to 14 mg/day for a 70 kg person). The reference dose is an estimate of the daily exposure of the human population to a potential hazard that is likely to be without risk of deleterious effects during a lifetime.

The most likely pathway by which humans may be exposed to toluene is by breathing toluene in air (ATSDR 1989). The U.S. EPA estimated that a typical absorbed dose based on inhalation is 0.32 mg/day assuming an air exposure concentration of 34 $\mu g/m^3$. Intake from food and water may contribute smaller amounts and smoking may contribute 1 or more mg/day. Higher exposure levels might occur for individuals living near an industrial source of toluene emissions, but the significance of this can only be evaluated on a site-specific basis.

In Canada, the estimated total average daily intakes of toluene for various age groups in the population ranged from 0.0016 to 0.0216 mg/kg body weight (Government of Canada 1992). Moreover, the daily intake is considered to be well below levels that a person can be exposed to over a lifetime without deleterious effects. Hence, the Ministers of Environment Canada and Health and Welfare Canada concluded that current concentrations of toluene in the environment do not constitute a danger in Canada to human life or health.

The purpose of this document is to develop a Provincial Water Quality Guideline for toluene for the protection of aquatic life. Toluene was identified as a priority for guideline development because it was deemed to be a substance of environmental concern and was present in industrial point source discharges to Ontario surface waters. In addition, a guideline for the protection of aquatic life was developed because toluene is a common pollutant released into water through chemical spills.

1.1 SOURCES OF TOLUENE IN THE ENVIRONMENT

Toluene may enter the environment from discharges or spills (including petroleum spills) associated with its use, production, storage and transportation (Fishbein 1985). Atmospheric emissions are expected from industries by way of process and fugitive emissions and evaporation from wastewater streams. Also, it is anticipated that process residues and sludges containing these chemicals may enter landfills.

Toluene has been detected in the effluents of various industries monitored in Ontario under the MISA (Municipal Industrial Strategy for Abatement) Program. These industries were associated with the Organic Chemical Manufacturing (OCM), Petroleum Refining, Inorganic Chemicals, Pulp and Paper, Iron and Steel, Metal Casting, Industrial Minerals, and Metal Mining sectors.

In the OCM sector, toluene was detected in effluents indicating point source inputs to the St. Clair and St. Lawrence rivers and in the vicinity of Elmira and Thorold. Average concentrations ranged from 0.0004 to 0.050 mg/L among the important dischargers to the environment located on the St. Clair River (MOEE unpublished data, 1989-1991). The total sector loading of toluene is approximately 6 kg/day..

In the Petroleum sector, toluene was detected in 16 percent of the samples for all 7 refineries located in Ontario. The average concentration was 0.0004 mg/L indicating potential inputs to the St. Clair River near Sarnia, Lake Erie near Nanticoke, and Lake Ontario near Oakville (MOE 1990).

Average concentrations of toluene detected in discharges for the Inorganic Chemicals sector ranged up to 0.003 mg/L indicating inputs to the to the St. Clair River near Sarnia, the Detroit River at Amherstburg, the Welland River, Lake Gibson (Thorold), and the St. Lawrence River at Maitland and Cornwall (MOEE unpublished data, 1990-1991).

Average concentrations of toluene detected in Pulp and Paper sector effluents ranged from 0.00013 to 0.023 mg/L in 1990 (Environment Ontario 1991). In 1990, there were 27 pulp and paper mills located in Ontario in areas such as Fort Francis, Dryden, Thunder Bay, Marathon, Espanola, Iroquois Falls, St. Catharines, Trenton, Ottawa, and Cornwall.

The average concentration of toluene detected in Iron and Steel sector effluents ranged from 0.0004 to 0.0034 mg/L indicating inputs to Hamilton harbour and the Ottawa river during 1990-91 (Hamdy 1991). Also, toluene was detected in the Metal Casting, Industrial Minerals,

and Metal Mining sectors at levels generally less than 0.001 mg/L (MOEE unpublished data, 1990-91).

1.2 ENVIRONMENTAL FATE AND PROPERTIES

The physical and chemical properties of toluene are shown in Table 1. Toluene is moderately soluble in water. The high Henry's Law Constant and vapour pressure indicate toluene is highly volatile.

In the aquatic environment, toluene will be removed by both volatilization and biodegradation (Howard 1990; Callahan et al. 1979). The predominant removal process will depend on water temperature, mixing conditions, and the existence of acclimated microorganisms at the site. The overall half-life of toluene in surface water may range from days to several weeks (Howard 1990). The half-life for volatilization of toluene from a water column one metre deep has been reported to range between 30 minutes and 5 hours (Mackay and Wolkoff 1973; Mackay and Leinonen 1975; Thomas 1982).

Toluene is readily degradable in a variety of standard biodegradability tests (reviewed by Howard 1990). For example, after seven days at 23°C, a concentration of less than 5 mg/L of toluene remained in an industrial microbial test system initially dosed with 50 mg/L (Davis et al. 1981).

Toluene will not significantly hydrolyze, photolyze, adsorb to sediment, or bioconcentrate in aquatic organisms (Howard 1990). The potential for toluene to bioaccumulate is discussed further in section 3.0.

When released onto soil, toluene will evaporate into the atmosphere and may leach into groundwater, especially in soil with low organic carbon content (Howard 1990). However, toluene may be relatively persistent in groundwater where volatilization is not a viable process. Also, biodegradation will occur although the extent will depend on the microbes

present, the concentration of toluene, the presence of other compounds, and the amount of oxygen present.

Once in the atmosphere, toluene will be transported until it removed by physical (i.e., partitioning into clouds or rainwater) or chemical processes (ATSDR 1989). Toluene will principally be removed by chemical transformations caused by the suns energy (photooxidation) with a half-life of less than 2 days (ATSDR 1989; Howard 1990).

Toluene has been detected throughout North America in effluents from municipalities and industries, industrialized river basins, groundwater, sediments, soil and air (ATSDR 1989; Howard 1990; Fishbein 1985). Despite its widespread presence, physical, chemical and biological processes can remove toluene in all media and reduce environmental exposures. Hence, ambient levels remain low because of photooxidation in air and high volatility from water and soil.

In 1986, a survey was undertaken to investigate the potential impact of point source discharges to the St. Clair River (Environment Ontario 1991). Water samples were collected from 43 stations located throughout the river in May, July, and October. Toluene was not detected in 284 samples collected at the detection limit of 0.001 mg/L.

As part of the Ontario Drinking Water Surveillance Program which includes raw water samples collected from surface and ground waters from urbanized areas located throughout the Great Lakes basin, toluene was usually not detectable (MOEE unpublished data, 1992). Toluene was detected at a few sites at levels up to 0.00025 mg/L. The MOEE routine analytical detection limit for toluene in water is 0.00005 mg/l. The Canadian Drinking Water Guideline for public water supplies is 0.024 mg/L (aesthetic objective).

In the United States, toluene was detected in soil samples collected at hazardous waste sites studied by the Environmental Protection Agency at levels averaging 0.077 mg/kg (ATSDR

1989). In a survey of 7 landfill sites tested in Ontario, toluene was detected in leachate at levels ranging from 0.001 to 0.6 mg/L (MOEE unpublished data, 1988).

As part of the MOEE Volatile Organic Compounds Monitoring Network, ambient air concentrations of toluene for six cities (Thunder Bay, Sault Ste. Marie, Windsor, Toronto, and Hamilton) ranged from not-detectable (less than 0.1 $\mu g/m^3$) to 52 $\mu g/m^3$ (Environment Ontario 1992). This upper level was found in Windsor, although the average concentration here was 12 $\mu g/m^3$. In general, measured concentrations were less than 10 $\mu g/m^3$. The Ontario ambient air quality criterion or acceptable level is 2000 $\mu g/m^3$.

In summary, toluene is rapidly degraded by photochemical oxidation in the atmosphere. Toluene in water or soil will volatilize to air and that which remains is subject to microbial degradation. As a result, there is little tendency for toluene levels to build up in the environment over time.

2.0 AQUATIC TOXICITY

Criteria used for classifying available toxicity data as either primary or secondary information are described in "Ontario's Water Quality Objective Development Process" (Environment Ontario 1992). In general, primary toxicity studies involve acceptable test procedures, conditions, and controls, measured toxicant concentrations, and flow through or renewal exposure conditions. Secondary toxicity studies usually involve unmeasured toxicant concentrations, static bioassay conditions, and unsatisfactory reporting of experimental data. Generally, acute toxicity studies involve test durations of 96 hours or less for vertebrates or 48 hours or less for invertebrates. Chronic toxicity data studies include complete life cycle tests and partial life cycle tests involving early life stages.

2.1 ACUTE TOXICITY

2.1.1 Vertebrates

Primary acute toxicity data for animals exposed to toluene were available for early life stages of fathead minnow (Pimephales promelas), goldfish (Carassius auratus), guppy (Lebistes reticulatus), rainbow trout (Oncorhynchus mykiss) and coho salmon (Oncorhynchus kisutch) fry (Table 2). Primary 96h-LC50 values ranged from 5.46 mg/L for coho salmon fry (Moles et al. 1981) to 72 mg/L for fathead minnow embryos (Devlin et al. 1982). The lowest reported 96h-LC50 values for rainbow trout and fathead minnow fry were 5.8 and 18 mg/L, respectively (Galassi et al. 1988; Devlin et al. 1982).

Secondary acute toxicity data were available for fathead minnow, goldfish, rainbow trout, bluegill sunfish (Lepomis macrochirus), guppy , channel catfish (Ictalurus punctatus), golden orfe (Leuciscus idus), and mosquito fish (Gambusia affinis) (Table 2). 96h-LC50 values ranged from 12.6 mg/L for fathead minnow (Liu et al. 1983) to 1180 mg/L for mosquito fish (Wallen et al. 1957). It is important to note that the 24, 48 and 96h-LC50 values reported by Wallen et al. (1957) exceed the solubility of toluene in pure water.

2.1.2 Invertebrates

In a study considered as primary data, Galassi et al. (1988) reported a 24h-EC50 of 7 mg/L for the immobilization of water fleas (Daphnia magna). Also, secondary acute toxicity data were available for Daphnia magna. LC50 or EC50 values for Daphnia magna ranged from 11.5 mg/L (Bobra et al. 1983) to 310 mg/L (LeBlanc 1980).

2.2 CHRONIC TOXICITY

2.2.1 Vertebrates

Primary chronic toxicity data were available for coho salmon, rainbow trout, goldfish, fathead minnow, salamander (Ambystoma gracile), and leopard frog (Rana pipiens) (Table 3). Moles et al. (1981) reported effect concentrations of 2.76 and 5.00 mg/L for significantly reduced growth of coho salmon fry after 40 days of exposure. LC50 values, derived from long term exposures, ranged from 0.02 mg/L for rainbow trout (Black et al. 1982) to 44.1 mg/L for fathead minnow (Hall et al. 1984,1989). Brenniman et al. (1976) reported a 30d-LC50 of 14.58 mg/L for goldfish. Hall et al. (1984, 1989) reported an 8d-LC50 of 44.1 mg/L for fathead minnow. In addition, Black et al. (1982) reported median lethal concentrations of 0.85 and 1.09 mg/L for early life stages of salamander and median lethal concentrations of 0.39 and 0.51 mg/L for early life stages of frogs.

In studies considered secondary data, Stoss and Haines (1979) reported a 96h-LC50 of 54 mg/L for medaka embryos (Oryzias latipes) and Könemann (1981) reported a 14d-LC50 of 68.3 mg/L for guppy (Poecilia reticulata).

In a study considered as ancillary information, Devlin et al. (1985) exposed fathead minnow embryos (1-2 hours old) to 30 to 45 mg/L of toluene for up to 124 hours. The chorion of toluene-treated embryos were found to be cloudy, fragile and covered with a white gelatinous material. Embryo-toxic effects noted included a curved embryonic axis, abnormal heart and circulatory system development, hydration and swelling of the pericardial coelom, haemorrhaging, microphthalmia, enlarged yolk sac, and an overall stunted appearance and retarded development. Virtually all tissues of toluene exposed embryos were abnormal.

2.2.2 Invertebrates

No chronic toxicity studies for exposed invertebrates were available. However, Hermens et al. (1984) calculated a 16d-LC50 of 3.75 mg/L based on quantitative structure-activity relationships (QSAR).

2.2.3 Other Organisms (Plants, Protozoa, Rotatoria, and Bacteria)

As defined by Environment Ontario (1992), secondary chronic toxicity data were available for algae, rotatoria, and protozoa (Table 3). The lowest reported adverse effect concentration was a 72h-EC50 of 12.5 mg/L for algae, Selenastrum capricornutum (Galassi et al. 1988). Erben (1978) found an EC40 of approximately 173 mg/L for rotifers (Dicranophorus forcipatus). In addition, Schultz et al. (1978) found a 24h-LC100 of 550 mg/L for protozoa (Tetrahymena pyriformis).

2.3 SUMMARY OF TOXICITY DATA

The ranges of toxicity exhibited by aquatic organisms exposed to toluene are summarized in Figure 1. Acute toxicity data were available for both cold water and warm water fish species. Primary 96h-LC50 values ranged from 5.46 mg/L for coho salmon fry (Moles et al. 1981) to 72 mg/L for fathead minnow embryos (Devlin et al. 1982).

Limited primary acute toxicity information was available for invertebrates. Galassi et al. (1988) reported a 24h-EC50 of 7 mg/L (immobilization) for water fleas.

Primary chronic toxicity data were available for cold and warm water fish species and early life stages of frogs and salamanders. LC50 values, derived from long term exposures, ranged from 0.02 mg/L for early life stages of rainbow trout (Black et al. 1982) to 44.1 mg/L for fathead minnows (Hall et al. 1984, 1989).

No chronic toxicity data were found for macro-invertebrates exposed to toluene. The lowest reported adverse effect concentrations for algae (Selenastrum capricornutum), rotifers (Dicranophorus forcipatus), and protozoa (Tetrahymena pyriformis) were 12.5 mg/L (72h-EC50), approximately 173 mg/L (6d-EC40), and 550 mg/L (24h-LC100), respectively (Galassi et al. 1988; Erben 1978; Schultz et al. 1978).

3.0 BIOACCUMULATION

The log Kow for toluene is 2.7 which is characteristic of a compound with a low potential for bioaccumulation (Hawker and Connel 1988; Lyman et al. 1982). Veith et al. (1980) calculated a bioconcentration factor (BCF) of between 15 and 70. The alga, Chlorella fusca, concentrated toluene by a factor of 380 (Geyer et al. 1984). In conclusion, toluene is not expected to undergo significant bioaccumulation in aquatic organisms.

4.0 MUTAGENICITY

The genotoxic effects of toluene have been recently reviewed (IRIS 1992; GENETOX 1992; ATSDR 1989; Fishbein 1985). In summary, genotoxicity studies have provided negative results in a variety of assays using bacteria (Salmonella and Escherichia coli strains) in the presence and absence of metabolic activation or yeast (Saccharomyces cerevisiae). Administration of toluene to mice did not induce dominant lethal mutations in sperm cells. There was no evidence of chromosomal aberrations in blood lymphocytes of workers exposed to toluene only and there was no evidence of chromosomal aberrations or sister chromatid exchanges in cultured human lymphocytes exposed to toluene in vitro. However, two isolated studies reported that toluene was effective in causing chromosomal damage in bone marrow cells of rats (Lyapkalo 1973; Dobrokhotov 1972).

A review of the scientific literature indicated there was no mutagenicity or genotoxicity information available for aquatic plants and animals exposed to toluene. As a result, there is

insufficient information available to develop a numerical criterion for the protection of aquatic life.

Although the majority of the data suggest that toluene is not genotoxic, the two studies that did show positive results suggest that toluene may have the potential for causing genotoxicity in aquatic organisms.

5.0 ODOUR AND TASTE

Zoeteman et al. (1971) reported a threshold odour concentration (T.O.C.) of 1 mg/L for toluene in water at 15 °C. Toluene in water was reported to taint or impair the taste of yellow perch (Perca fluvatilus) at concentrations ranging from 0.25 to 50 mg/L (as reviewed by Persson 1984).

Alexander et al. (1982) measured aqueous taste and odour thresholds for toluene in odour-free water. The average taste threshold was 0.14 mg/L at 40 °C. The average odour threshold was 0.024 mg/L at 60 °C. However, this odour threshold value is not considered representative of ambient conditions because aquatic temperatures are usually much lower. Also, this study showed that odour threshold values for several volatile substances were consistently higher at lower temperatures (i.e., 20 °C).

6.0 DERIVATION OF WATER QUALITY GUIDELINE

Since the toxicological database for toluene was limited, a Provincial Water Quality Objective could not be developed. Therefore, following standard procedures as outlined in Environment Ontario (1992), the process reverted to the derivation of a Provincial Water Quality Guideline for the protection of aquatic life.

Where guidelines are set to protect aquatic life, the number is derived by dividing the lowest adverse effect concentration by an "uncertainty factor". The size of the uncertainty factor reflects the quality and quantity of data available and the potential of the material to bioaccumulate.

The Federal-Provincial Working Group on recreational water quality has not recommended limits for chemicals in recreational water for human exposure because of the lack of sufficient scientific information (Health and Welfare Canada 1992). Therefore, a recreational use water quality guideline for the protection of human health is not recommended at this time.

Humans exposed to aqueous solutions of toluene may absorb toluene through the skin (ATSDR 1989). Brown et al. (1984) estimated that concentrations of toluene at 0.005 to 0.5 mg/L would result in daily doses of 0.0002 to 0.02 mg/kg body weight (equivalent to 0.0014 to 1.4 mg per day for a 70 kg adult) while swimming for 15 minutes and consuming contaminated water. Since toluene in Ontario surface waters is present at much lower concentrations (i.e., less than 0.001 mg/L) or is not detectable, this suggests that exposure through skin contact with water is likely insignificant.

6.1 CALCULATION OF THE FINAL UNCERTAINTY FACTOR

The choice of a baseline uncertainty factor depends upon the octanol-water partition coefficient (Kow) of the substance (which is a useful indicator of bioaccumulation potential). Chiou and Schmedding (1982) reported a measured log Kow of 2.7 for toluene and Mabey et

al. (1982) reported an estimated log Kow of 2.8. Therefore, a baseline uncertainty factor of 1000 was selected, since the measured log Kow for toluene was less than 4 (Environment Ontario 1992).

The final uncertainty factor was calculated based on the following toxicity information (Table 4):

A. The following studies were used in the chronic toxicity data category:

1. The 30-day LC50 of 14.58 mg/L for goldfish (C. auratus) was considered primary chronic toxicity information (Brenniman et al. 1976). The fish were exposed under continuous flow conditions with measured toxicant concentrations.

2. The 27-day LC50 of 0.02 mg/L for rainbow trout (Oncorhynchus mykiss) embryos was considered as primary toxicity information (Black et al. 1982). Toxicant concentrations were measured throughout this test which involved continuous flow exposure conditions and covered test chambers.

3. The lowest observed effect concentration of 2.76 mg/L for significantly reduced growth of Coho salmon (Oncorhynchus kisutch) was considered as primary toxicity information (Moles et al. 1981). This study involved a flow-through system with measured toxicant concentrations.

4. The estimated 16-day LC50 of 3.75 mg/L for cladoceran (D. magna), based on quantitative structure-activity relationships, was considered tertiary chronic toxicity information (Hermens et al. 1984).

5. The 6d-EC40 (cell culture growth) of approximately 173 mg/L for the rotifer (Dicranophorus forcipatus) was considered secondary toxicity information and used in the invertebrate category as defined by Environment Ontario (1992). This study

involved unmeasured toxicant concentrations and static exposure conditions (Erben 1978).

6. The 72h-EC50 (growth) of 12.5 mg/L for algae (Selenastrum capricornutum) was considered secondary information (Galassi et al. 1988). This study involved static conditions and measured toxicant concentrations.

B. The following studies were used in the acute toxicity data category:

1. The 96h-LC50 of 18 mg/L for fathead minnow (Pimephales promelas) was considered primary acute toxicity information (Devlin et al. 1982). This study involved flow through conditions and measured toxicant concentrations.

2. The 96h-LC50 of 5.8 mg/L for rainbow trout was considered primary acute toxicity information (Galassi et al. 1988). This test involved renewal exposure conditions in sealed containers and measured toxicant concentrations.

3. The 96h-LC50 of 5.46 mg/L for coho salmon fry (Oncorhynchus kisutch) was considered primary toxicity information (Moles et al. 1981). This test involved flow through conditions and measured toxicant concentrations.

4. The 24h-EC50 (immobilization) of 7.0 mg/L for 24 hour old cladoceran (D. magna) was considered primary toxicity information (Galassi et al. 1988). This test involved static exposure conditions in closed bottles and measured toxicant concentrations.

Based on the above data and applying the appropriate calibration factors (Table 4), a value of 26 was derived as the final uncertainty factor.

6.2 CALCULATION OF THE GUIDELINE VALUE

The following guideline was set as a single value independent of other water quality parameters such as temperature. Since toluene is highly volatile, only primary studies were considered in selecting the lowest adverse effect concentration or critical value.

The lowest adverse effect concentration considered valid for developing a PWQG was a 27-day LC50 of 0.02 mg/L reported for rainbow trout in an embryo-larval test (Black et al. 1982). This value divided by the final uncertainty factor of 26 produced a preliminary Provincial Water Quality Guideline of 0.0008 mg/L (rounded to one significant figure) (Table 4 and Fig. 1).

For toluene in water, the lowest valid threshold odour concentration was 1 mg/L (Zoeteman et al. 1971). This value multiplied by a safety factor of 0.5 produced an odour protection value of 0.5 mg/L. Similarly, a tainting protection value of 0.13 mg/L and a taste protection value of 0.070 mg/L were derived by applying a safety factor of 0.5 to water concentrations found to impair the taste of yellow perch (0.25 mg/L) and the taste of water (0.14 mg/L), respectively (Section 5.0).

There was no information available to develop a numerical mutagenicity criterion for the protection of aquatic life, since no acceptable genotoxicity information for fish, invertebrates, or plants was found. Most of the available data suggest toluene is not genotoxic, although chromosomal damage by this compound was reported (Section 4.0). While the majority of evidence supports the classification of toluene as non-mutagenic, the possibility of its genotoxic hazard in aquatic organisms cannot be excluded.

Since the preliminary guideline value of 0.0008 mg/L based on toxicity is below the odour, tainting and taste protection values, the recommended Provincial Water Quality Guideline for the protection of aquatic life is 0.0008 mg/L. The MOEE routine analytical detection limit for toluene in water is 0.00005 mg/L ("clean" water analysis).

7.0 RESEARCH NEEDS

Additional toxicity studies involving freshwater macro-invertebrates are needed to fulfil the minimum data requirements for developing a PWQO.

8.0 AMBIENT WATER QUALITY CRITERIA OF OTHER AGENCIES

The CCREM (1987) recommended a Canadian water quality guideline of 0.3 mg/L for the protection of aquatic life.

The U.S. EPA has not developed a water quality criterion for the protection of freshwater biota, although they report 17.5 mg/L is the lowest effect concentration (LEC) for acute toxicity (IRIS 1992).

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TABLE 1: PHYSICAL-CHEMICAL PROPERTIES

CHEMICAL:	CHEMICAL FORMULA:	CAS No:
Toluene	C_7H_8	108-88-3

PROPERTIES

MOLECULAR WEIGHT (MW):	92.1 g/mol	Verschueren (1983)
MELTING POINT:	- 95.1 °C	Verschueren (1983)
BOILING POINT:	110.8°C	Verschueren (1983)
PHYSICAL STATE AT STANDARD TEMPERATURE AND PRESSURE:	liquid	
DENSITY (D):	0.867 g/cm^3 (20°/4°C)	Verschueren (1983)
MOLAR VOLUME (MW/D):	106.23 cm^3/mol (calc.)	
VAPOUR PRESSURE (Ps):	2933 Pa at 20°C	Verschueren (1983)
WATER SOLUBILITY (Cs):	515 mg/L at 20°C	Verschueren (1983)
HENRY'S LAW CONST.(Ps/Cs):	0.006 4 atm - m^3/mol	Howard (1990)

PERSISTENCE

SURFACE WATER HALF LIFE:	days to weeks	Howard (1990)
AQUATIC FATE:	volatilization and biodegradation	Howard (1990)

OCTANOL-WATER PARTITION COEFFICIENT (Kow)

RANGE OF AVAILABLE Log Kow VALUES:	2.7 (measured), 2.8 (est.)	Mabey *et al.* (1982)
FINAL CHOSEN Log Kow VALUE:	2.7	

BASELINE UNCERTAINTY FACTOR FOR GUIDELINE DEVELOPMENT

IF Log Kow < 4.00, USE 1000 IF Log Kow ≥ 4.00, USE 10000

BASELINE UNCERTAINTY FACTOR: 1000

TABLE 2: ACUTE AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
VERTEBRATES											
Fathead minnow (*Pimephales promelas*)	30 days old	96h-LC50	8.3	25			80	30	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	31	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	26	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	18	F/M	PA	Devlin et al., 1982
	protolarvae	96h-LC50	8.3	25			80	36	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	25	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25				27	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	28	F/M	PA	Devlin et al., 1982
	embryos	96h-LC50	8.3	25				72	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	66	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	59	F/M	PA	Devlin et al., 1982
		96h-LC50	8.3	25			80	55	F/M	PA	Devlin et al., 1982

KEY (1)	KEY (2)	KEY (3)
TLm = Median Tolerance Limit	S = Static	P = primary
LC = Lethal Concentration	F = Flowthrough	S = secondary
IC = Immobilization Concentration	U = Unmeasured Toxicant Concentration	T = tertiary
EC = Effects Concentration	M = Measured Toxicant Concentration	A = acute toxicity
	R = Renewed Static	C = chronic toxicity

TABLE 2: ACUTE AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Fathead minnow *(Pimephales promelas)*	10–15 days old fry	96h-LC50	7.6–8.3	22±1			96–125	56.4	S/M	SA	Mayes et al., 1983
	30–35 days juvenile	96h-LC50	7.6–8.3	22±1			96–125	77.4	S/M	SA	Mayes et al., 1983
	60–100 days subadult	96h-LC50	7.6–8.3	22±1			96–125	54.0	S/M	SA	Mayes et al., 1983
	3.8–6.4 cm (1–2g)	96h-TLm	7.5	25	7.8	18	20	34.27	S/U	SA	Pickering & Henderson, 1966
		96h-TLm	7.5	25	7.8	18	20	44	S/U	SA	Pickering & Henderson, 1966
		96h-TLm	8.2	25	7.8	300	350	42.33	S/U	SA	Pickering & Henderson, 1966
		96h-TLm	8.2	25	7.8	300	360	45	S/U	SA	Pickering & Henderson, 1966
	adult	96h-LC50	7.7±0.35	20		38±20	33.8±19	12.6	S/U	SA	Liu et al., 1983
	31 days old	96h-LC50	7.89±0.03	24.7±0.2	6.9±0.44	43.4±1.25	45.4+0.8	36.2	F/M	SA	Geiger et al., 1986

KEY (1)
TLm = Median Tolerance Limit
LC = Lethal Concentration
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EC = Effects Concentration

KEY (2)
S = Static
F = Flowthrough
U = Unmeasured Toxicant Concentration
M = Measured Toxicant Concentration
R = Renewed Static

KEY (3)
P = primary
S = secondary
T = tertiary
A = acute toxicity
C = chronic toxicity

TABLE 2: ACUTE AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Fathead minnow *(Pimephales promelas)*	3.8–6.4 cm (1–2g)	48h–TLm	7.5	25	7.8	18	20	46.31	S/U	SA	Pickering & Henderson, 1966
		48h–TLm	8.2	25	7.8	300	360	56	S/U	SA	Pickering & Henderson, 1966
		24h–TLm	7.5	25	7.8	18	20	46.31	S/U	SA	Pickering & Henderson, 1966
		24h–TLm	8.2	25	7.8	300	360	56	S/U	SA	Pickering & Henderson, 1966
	30–31 days old	96h–LC50	7.6±0.02	25.5±0.35	8.4±0.4	46.7±0.17	39.7±0.9	31.7	F/M	PA	Geiger et al., 1990
Goldfish *(Carassius auratus)*	1–1.5 year old	96h–LC50	7.0±0.3	17–19	>7.0	71	80	22.8	F/M	PA	Brenniman et al., 1976
	(13–20 cm)	72h–LC50	7.0±0.3	17–19	>7.0	71	80	25.33	F/M	PA	Brenniman et al., 1976
	(20–80g)	48h–LC50	7.0±0.3	17–19	>7.0	71	80	27.62	F/M	PA	Brenniman et al., 1976
		24h–LC50	7.0±0.3	17–19	>7.0	71	80	41.59	F/M	PA	Brenniman et al., 1976
	3.8–6.4 cm (1–2g)	96h–TLm	7.5	25	7.8	18	20	57.68	S/U	SA	Pickering & Henderson, 1966

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EC = Effects Concentration	M = Measured Toxicant Concentration	A = acute toxicity
	R = Renewed Static	C = chronic toxicity

TABLE 2: ACUTE AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Goldfish *(Carassius auratus)*		96h-TLm	7.5	25	7.8	18	20	62	S/U	SA	Pickering & Henderson, 1966
		48h-TLm	7.5	25	7.8	18	20	57.68	S/U	SA	Pickering & Henderson, 1966
		24h-TLm	7.5	25	7.8	18	20	57.68	S/U	SA	Pickering & Henderson, 1966
	6.2±0.7 cm (3.3±1.0g)	24h-TLm	7.8	20±1				58	S/M	SA	Bridie et al., 1979
Coho salmon *(Oncorhynchus kisutch)*	Fry 0.3g	96h-LC50		7.6-10.4	11.6			5.46	F/M	PA	Moles et al., 1981
	Fry 0.3g	96h-LC50						8.11	F/M	SA	Moles, 1980
Rainbow trout *(Oncorhynchus mykiss)*	2.4g	96h-LC50	7.2-7.5	12±1		30-35	40-50	24	S/U	SA	Johnson & Finley, 1980
		96h-LC50		12±1				5.8	R/M	PA	Galassi at al., 1988

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TABLE 2: ACUTE AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Bluegill sunfish *(Lepomis macrochirus)*	0.32g–1.2g	96h-LC50	6.7–7.8	22±1	7.0–8.8	28–34	32–48	13	S/M	SA	Buccafusco et al., 1981
	0.1g	96h-LC50	7.2–7.5	17±1		30–35	40–50	170	S/U	SA	Johnson & Finley, 1980
	1–2g	96h-TLm	7.5	25	7.8	18	20	24	S/U	SA	Pickering & Henderson, 1966
	(3.8–6.4 cm)	48h-TLm	7.5	25	7.8	18	20	24	S/U	SA	Pickering & Henderson, 1966
		24h-TLm	7.5	25	7.8	18	20	24	S/U	SA	Pickering & Henderson, 1966
	0.32–1.2g	24h-LC50	6.7–7.8	22±1	7.0–8.8	28–34	32–48	17	S/M	SA	Buccafusco et al., 1981
Guppy *(Lebistas reticulatus)*	1.9–2.5 cm	96h-TLm	7.5	25	7.8	18	20	59.3	S/U	SA	Pickering & Henderson, 1966
	(0.1–0.2g)	96h-TLm	7.5	25	7.8	18	20	66	S/U	SA	Pickering & Henderson, 1966
		48h-TLm	7.5	25	7.8	18	20	60.95	S/U	SA	Pickering & Henderson, 1966

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SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Guppy (*Lebistes reticulatus*)		24h-TLm	7.5	25	7.8	18	20	62.81	S/U	SA	Pickering & Henderson, 1966
		96h-LC50		21±1				28.2	R/M	PA	Galassi et al., 1988
Channel catfish (*Ictalurus punctatus*)	0.1g	96h-LC50	7.2-7.5	22±1		30-35	40-50	240	S/U	SA	Johnson & Finley, 1980
Mosquito fish (*Gambusia affinis*)		96h-TLm	7.5-8.5	17-22				1180	S/U	SA	Wallen et al., 1957
		24h-TLm	7.5-8.5	17-22				1340	S/U	SA	Wallen et al., 1957
		48h-TLm	7.5-8.5	17-22				1260	S/U	SA	Wallen et al., 1957
Golden orfe (*Leuciscus idus*)		48h-LC50						70	S/U	SA	Juhnke & Lüdemann, 1978
		48h-LC50						422	S/U	SA	Juhnke & Lüdemann, 1978

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INVERTEBRATES											
Cladoceran *(Daphnia magna)*	<24h old	48h-EC50	6.7-8.1	22±1	6.5-9.1		72±6	310	S/U	SA	LeBlanc, 1980
		48h-EC50	7.7±0.35	20		38±20	33.8±19	20.2	S/M	SA	Liu et al., 1983
	<24h old	24h-LC50	6.7-8.1	22±1	6.5-9.1		72±6	310	S/U	SA	LeBlanc, 1980
		No discernable effect	6.7-8.1	22±1	6.5-9.1		72±6	28	S/U	SA	LeBlanc, 1980
	<2d old	48h-EC50(Immob.)		22±1				14.93	S/M		Hermens et al., 1984
	24h old	24h-EC50(Immob.)						7	S/M	PA	Galassi et al., 1988
	<72h old	48h-EC50(Immob.)	6.0-7.0	23±2	5.0-9.0			11.5	S/U	SA	Bobra et al., 1983

KEY (1)
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M = Measured Toxicant Concentration
R = Renewed Static

KEY (3)
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S = secondary
T = tertiary
A = acute toxicity
C = chronic toxicity

TABLE 3: CHRONIC AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
VERTEBRATES											
Rainbow trout (*Oncorhynchus mykiss*)	Embryo exposed from fertilization to: hatch	23d-LC50	7.8±0.02	14.3±0.2	9.6±0.1		106.3±1.2	0.03	F/M	PC	Black et al., 1982
	4d posthatch	27d-LC50	7.8±0.02	14.3±0.2	9.6±0.1		106.3±1.2	0.02	F/M	PC	Black et al., 1982
Coho Salmon (*Oncorhynchus kisutch*)	fry	40d-sign. decr. wet & dry wt.		7.6-10.4				2.76	F/M	PC	Moles et al., 1981
		40d-sign. decr. wet & dry wt, & length		7.6-10.4				5.00	F/M	PC	Moles et al., 1981
Goldfish (*Carassius auratus*)	1-1.5 year old (13-20 cm 20-80 g)	30d-LC50	7.0±0.3	17-19	>7.0	71	80	14.58	F/M	PC	Brenniman et al., 1976
Guppy (*Poecilia reticulata*)	2-3 months old	14d-LC50		22±1	6		25	68.3	R/U	SC	Könemann, 1981

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SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
Fathead minnow *(Pimephales promelas)*	30–35d old	8d-LC50		25±2	6.3–8.2	38–44	43–48	44.1	F/M	PC	Hall et al., 1984, 1989
Medaka *(Oryzias latipes)*	embryos	96h-LC50		25				54	S/U	SC	Stoss & Haines, 1979
Salamander *(Ambystoma gracile)*	Embryos exposed from fertilization to: hatch	5.5d-LC50	7.7±0.02	20.2±0.5	7.5±0.1		98.9±0.9	1.09	F/M	PC	Black et al., 1982
	4d posthatch	9.5d-LC50	7.7±0.02	20.2±0.5	7.5±0.1		98.9±0.9	0.85	F/M	PC	Black et al., 1982
Leopard frog *(Rana pipiens)*	Embryos exposed from fertilization to: hatch	5d-LC50	7.7±0.02	20.2±0.5	7.5±0.1		98.9±0.9	0.51	F/M	PC	Black et al., 1982
	4d posthatch	9d-LC50	7.7±0.02	20.2±0.5	7.5±0.1		98.9±0.9	0.39	F/M	PC	Black et al., 1982

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SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
INVERTEBRATES											
Cladoceran *(Daphnia magna)*	<24h old	16d-LC50 (QSAR est.)						3.75		SC	Hermens et al., 1984
OTHER ORGANISMS											
Rotatoria *(Dicranophorus forcipatus)*		6d-EC40 (cell culture growth)						173	S/U	SC	Erben, 1978
ALGAE											
Chlamydomonas angulosa		3h-EC50 (photosynth.)						134		SC	Hutchinson et al., 1980
Chlorella vulgaris		3h-EC50						207		SC	Hutchinson et al., 1980
		10d-EC50 (growth)						245		SC	Kauss & Hutchinson, 1975
Scenedesmus quadricauda		cell multiplication inhibition test toxicity threshold						>400		TC	Bringmann & Kuhn, 1980
Selenastrum capricornutum		72h-EC50 (growth)						12.5	S/M	SC	Galassi et al., 1988

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TABLE 3: CHRONIC AQUATIC TOXICITY DATA FOR TOLUENE

SPECIES	LIFE STAGE	RESPONSE KEY (1)	TEST CONDITIONS pH	TEMP. (°C)	D.O. (mg/L)	ALK. (mg/L)	HARD. (mg/L)	EFFECT CONC. (mg/L)	DATA CODES KEY (2)	DATA QUALITY KEY (3)	REFERENCES
BACTERIA											
Pseudomonas putida		cell multiplication inhibition test toxicity threshold						29		TC	Bringmann & Kuhn, 1980
PROTOZOA											
Tetrahymena pyriformis		24h-LC100						550	S/U	TC	Schultz et al., 1978
Entosiphon sulcatum		cell multiplication inhibition test toxicity threshold						>456		TC	Bringmann & Kuhn, 1980

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Table 4: UNCERTAINTY FACTOR WORKSHEET

CHEMICAL:	CAS No.	CONCENTRATION UNITS
TOLUENE	108-88-3	mg/L

Test Conditions		Species (life stage)	Toxicity End Point	Effect conc.	Data Codes [1]	Data Type [2]	Calibration Factor	Reference
ACUTE	VERTEBRATE	Fathead minnow, 30d	96h-LC50	18	F/M	1°	0.8	Devlin *et al.* 1982
		Rainbow trout	96h-LC50	5.8	R/M	1°	0.8	Galassi *et al.* 1988
		Coho salmon, fry	96h-LC50	5.46	F/M	1°	0.8	Moles *et al.* 1981
	INVERT.	*Daphnia magna*	24h-EC50 (imm.)	7.0	R/M	1°	0.8	Galassi *et al.* 1988
CHRONIC	VERTEBRATE	Goldfish, 1.0-1.5y old	30d-LC50	14.58	F/M	1°	0.5	Brenniman *et al.* 1976
		Rainbow trout, embryo	27d-LC50	0.02	F/M	1°	0.5	Black *et al.* 1982
		Coho salmon, fry	40d-sign. gr. red	2.76	F/M	1°	0.5	Moles *et al.* 1981
	INVERT.	*Daphnia magna, <24h*	16d-LC50 (QSAR)	3.75		3°	0.8	Hermens *et al.* 1984
		Dicranophorus forcipatus	6d-EC40 (gr)	173	S/U	2°	0.7	Erben 1978
	PLANT	*Selenastrum capricornutum*	72h-EC50 (gr.)	12.5	R/M	2°	0.9	Galassi *et al.* 1988

CALCULATION OF FINAL UNCERTAINTY FACTOR:

Since Log Kow < 4.00, The Baseline Uncertainty Factor = 1000

Baseline Uncertainty Factor X Calibration Factors (maximum number = 11)

1000 X 0.8 X 0.8 X 0.8 X 0.8 X 0.5 X 0.5 X 0.5 X 0.8 X 0.7 X 0.9 X

= 26 FINAL UNCERTAINTY FACTOR

CRITICAL VALUE ÷ FINAL UNCERTAINTY FACTOR = PWQG

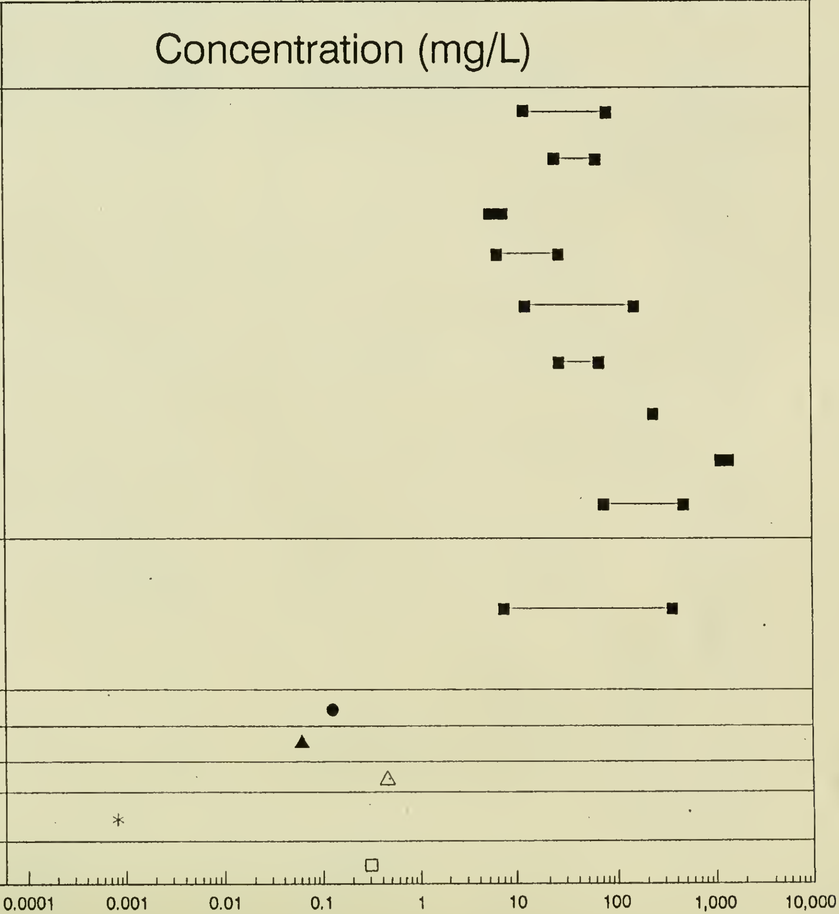
= 0.02 ÷ 26 = 0.0008 mg/L

[1] Assign 2 DATA CODES, one from each of the following rows:
S = static R = static/renewal F = flowthrough
U = unmeasured nominal conc. M = measured conc.

[2] DATA TYPE:
1° = Primary 2° = Secondary 3° = Simulated Data

FIG. 1: TOXICITY SUMMARY AND GUIDELINE DERIVATION GRAPH

Toxicity Information Considered		Species and Life Stage	Toxicity End-point
ACUTE	Vert.	Fathead minnow, various	various TLm/LC50
		Goldfish, various	various TLm/LC50
		Coho Salmon, fry	96h-LC50
		Rainbow trout, 2.4g	96h-LC50
		Bluegill sunfish, 0.1-2.0g	various TLm/LC50
		Guppy, 0.1-0.2g	various TLm/LC50
		Channel catfish, 0.1g	96h-LC50
		Mosquito fish	24/48/96h-TLm
		Golden Orfe	48h-LC50
	Invert.	*Daphnia magna, <72h old*	24/48h-EC50/LC50
Tainting Protection Value			0.13 mg/L
Taste Protection Value			0.07 mg/L
Odour Protection Value			0.5 mg/L
Provincial Water Quality Guideline			0.0008 mg/L
Other Criteria		CCREM	0.3 mg/L



○- Critical Value ∗-PWQG ■ - Toxicity endpoints △- Odour Protection Value ▲- Taste Protection Value □ - Criteria of Other Agencies ● -Tainting Protection Value

FIG. 1: TOXICITY SUMMARY AND GUIDELINE DERIVATION GRAPH